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OFFICE OF EXPERIMENT STATIONS—BULLETIN 219.
A. C. TRUE, Director.

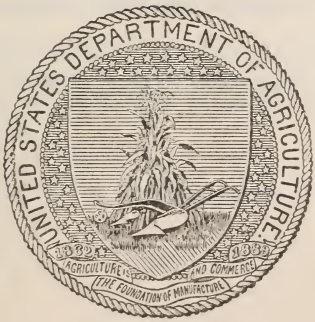
IRRIGATION IN NORTH DAKOTA.

BY

T. R. ATKINSON,
State Engineer.

PREPARED UNDER THE DIRECTION OF

SAMUEL FORTIER,
Chief of Irrigation Investigations.



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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Office of Experiment Stations,
Washington, D. C., July 12, 1909.

Sir: I have the honor to transmit herewith a report on irrigation in North Dakota, prepared by T. R. Atkinson, State engineer of that State. This is one of a series of reports giving the present status of irrigation in the several arid States. There is a very large call upon this Office for general information regarding the opportunities for settlement on irrigated lands in these States, the cost of land and water and of establishing homes on these lands, and regarding the crops grown. The attempt has been made to include in each of these reports as nearly as possible all the information which will be needed by those contemplating settlement in the State to which it refers. It is recommended that the report be published as a bulletin of this Office.

Respectfully,

A. C. True,
Director.

Hon. James Wilson,
Secretary of Agriculture.

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IRRIGATION IN NORTH DAKOTA.

INTRODUCTION.

North Dakota is 320 miles long, 210 miles wide, and contains 44,800,000 acres. It is distinctively a prairie State. It has few hills of sufficient size to be called mountains, the only ones receiving this appellation being the Turtle Mountains, covering an area of 100 square miles, near the center of the north boundary line, and the Pembina Mountains, a range of low foothills in Pembina County. There are also a few sharp peaks in Dunn County with an area of 10 square miles, called "Kildeer Mountains." The land west from the Red River of the North for a distance varying from 20 to 40 miles was originally the bed of glacial Lake Agassiz and is known as the "Red River Valley." The eastern parts of the counties of Richland, Cass, Traill, Grand Forks, Walsh, and Pembina are situated in this valley. The soil is noted for its fertility and produces abundant crops of No. 1 hard wheat as well as oats, barley, flax, potatoes, and all other root crops grown in northern latitudes.

The farmers in this valley have been gradually diversifying their crops for the past ten years and are beginning to realize the value of dairying and stock raising. A considerable increase in acreage of corn is being made annually, and a yield is resulting that compares favorably with that in southern Minnesota and Iowa. Crops of timothy, red clover, and alfalfa yielding 2 tons per acre at each of two cuttings are being grown in this valley. A little demonstration will prove to the wheat farmer the value of keeping dairy cows, thus enabling him to feed the small grains and retain on his land the fertility now being shipped out of the State.

The principal rivers draining the State are the Missouri, which enters the State about 65 miles south of its northwest corner, flows in a general southeasterly direction, and leaves the State just west of the one hundredth meridian; Mouse River, which enters the State about 90 miles east of the northwest corner and flows southeasterly through the eastern part of Ward County, then in 30 miles reverses its course and, flowing northwesterly, returns into the Dominion of Canada, 45 miles east of its point of entrance into North Dakota, its total length in this State being 180 miles; Red River of the North,

formed by the confluence of the Ottertail and the Bois de Sioux, 25 miles north of the south boundary line, and which forms the eastern boundary of the State and drains the famous Red River Valley; James River, which rises in the central part of the State, flows easterly and southerly into South Dakota and eventually empties into Missouri River. (Pl. I.)

The several streams of consequence which discharge into Red River, commencing at the south, are as follows: Wild Rice, Sheyenne, Elm, Goose, Turtle, Forest, Park, and Pembina. Red River has an average fall of about 6 inches per mile.

During the seasons of 1905–6 topographical surveys of the eastern part of the counties of Cass, Traill, Grand Forks, Walsh, and Pembina were made under the direction of John T. Stewart, drainage engineer, for the Office of Experiment Stations of this Department, in cooperation with the State engineer's office. Mr. Stewart's report [a] and plats show the elevation of points one-fourth mile apart along all east and west section lines for an average distance of 15 miles west from the river. They are very clear and comprehensive.

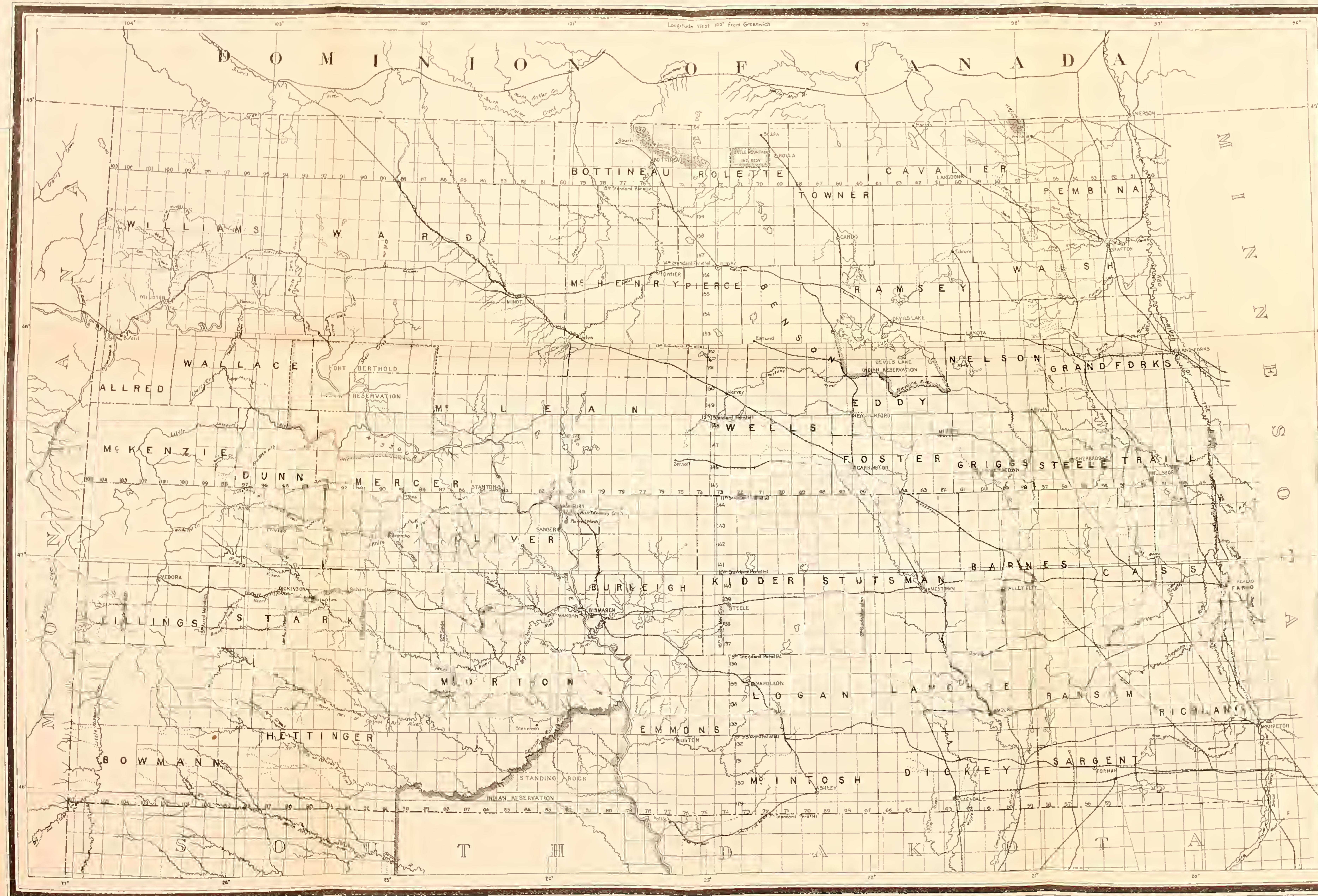
The area drained by the James River in North Dakota comprises 3,200,000 acres of rolling land of somewhat lighter soil than that of the Red River Valley, but successful mixed farming is practiced throughout the entire area.

The area drained by the Mouse River contains soil as fertile as that of the Red River Valley and practically all of it has been settled since the year 1900. The farmers are among the most prosperous in the State. Improved lands in this area are held at $25 to $50 per acre, depending on the value of the improvements, while wild land is valued at $15 to $30 per acre.

The area drained by the Missouri River comprises nearly one-half of the State, or 20,000,000 acres. This area is a rolling prairie land suitable for mixed farming and stock raising, and has been settled quite rapidly during the past six years. Dry farming is practiced, and the territory is well suited for the growing of durum wheat, which during the past few years has been grown extensively. After the extension of the Northern Pacific Railway in 1880 this country was occupied by the large stockmen, who ranged thousands of head of horses and cattle. Now it has become the home of thousands of settlers.

The principal industries, as already stated, are farming and stock raising. The distance from the markets for raw material and the scarcity of labor make the production of manufactured goods, except flour, expensive. Many flour mills throughout the State are producing the highest quality of flour, large quantities of which are

[a] U. S. Dept. of Agr., Office of Experiment Stations Bul. 189.



MAP OF NORTH DAKOTA, SHOWING STREAMS AVAILABLE FOR IRRIGATION.

THE NORRIS PETERS CO., WASHINGTON, D. C.

being shipped to the extreme Eastern States and to foreign countries. Good labor is scarce for the reason that no matter how poor a man is when he arrives in this State if he is willing to work and is endowed with an average amount of intelligence he will soon be in the position of employer himself. The opportunities for advancement from poverty to affluence for those who are willing to work are not surpassed probably by many States of the Union.

The population of the State, according to the census of 1905, was 437,070. Since 1905 it is estimated to have increased to over 500,000, the large increases having been in the counties of Billings, Bowman, Stark, and Ward.

The valuation of the real estate and personal property as returned by the State board of equalization in August, 1908, was $228,767,262. The assessment is based upon a 40 per cent valuation. About 10,000,000 acres of the State was in crop in 1908.

The mean monthly and annual precipitation, temperature, and the average date of killing frosts in different localities in the State, as obtained from the reports of the United States Weather Bureau, are as follows:

Average precipitation and mean temperature in North Dakota.

Month.	Bismarck.		Dickinson.		Williston.		Moorhead, Minn.	
	Mean temperature.	Average precipitation.	Mean temperature.	Average precipitation.	Mean temperature.	Average precipitation.	Mean temperature.	Average precipitation.
	°F.	*Inches.*	°F.	*Inches.*	°F.	*Inches.*	°F.	*Inches.*
January	7.7	0.54	10.2	0.43	6.5	0.58	2.7	0.71
February	8.3	.50	11.7	.48	7.9	.47	7.0	.73
March	22.1	1.04	23.6	.97	21.6	.68	21.4	1.14
April	42.6	1.88	42.6	1.17	40.5	1.23	41.4	2.33
May	55.2	2.50	52.8	2.37	54.3	2.26	54.8	2.95
June	64.2	3.54	61.1	2.82	63.5	3.57	64.3	4.13
July	70.2	2.14	68.0	2.18	69.4	2.03	68.7	3.74
August	68.1	1.98	67.5	1.85	67.9	1.31	65.9	3.10
September	57.1	1.19	56.5	1.00	59.5	.91	56.6	2.30
October	44.1	1.03	44.2	.58	42.9	.77	42.8	2.07
November	26.0	.68	27.0	.59	25.2	.60	24.4	.98
December	15.0	.62	18.7	.51	13.6	.66	10.7	.74
Annual	40.0	17.64	40.3	14.95	39.4	15.07	38.4	24.92

Average dates of killing frosts.

Locality.	Average date of last frost in spring.	Average date of first frost in autumn.	Locality.	Average date of last frost in spring.	Average date of first frost in autumn.
Bismarck	May 11	Sept. 17	Williston	May 15	Sept. 10
Dickinson	May 10	Sept. 15	Moorhead	May 10	Sept. 15

The distribution of rainfall throughout the State is in the ordinary season such that it is most propitious for the growing crops. The long period of sunshine during the growing days rushes the growth so

that in nearly every season all crops are matured sufficiently not to be injured by the earliest killing frosts in the fall.

North Dakota is well provided with railroads. Two transcontinental lines cross the State from east to west, namely, the Northern Pacific and the Great Northern, while one transcontinental line, the Minneapolis, St. Paul and Sault Ste. Marie, crosses from southeast to northwest, and the Pacific coast extension of the Chicago, Milwaukee and St. Paul cuts northwesterly across the most southwestern counties of Adams and Bowman. With their numerous extensions and branches, which are continually being constructed, the railroad transportation facilities are exceptionally good. Much of the grain is shipped to Duluth, Minn., and Superior, Wis., the heads of navigation on the Great Lakes, and most of the coal used in the eastern part of the State is brought by the lake route, thus securing cheap transportation to and from the East.

WATER RESOURCES.

North Dakota's irrigation code was enacted by the legislature during the session of 1905. It provides for a State engineer, who was appointed and took charge of the newly-created office March 1, 1905. Up to 1905 irrigation was comparatively new in the State, having been practiced by only a few individuals. These used only the methods that they themselves had devised and which were carried on at the expenditure of much hard labor and time.

The State engineer has cooperated with the engineers of the Reclamation Service, and many preliminary surveys have been made each season for the purpose of bringing to the attention of the service projects of sufficient magnitude to interest their engineers and warrant further surveys and construction if found feasible, as North Dakota is one of the States included under the provisions of the Reclamation Act.

Acting upon the suggestion of Major Powell, then Director of the United States Geological Survey, the constitutional convention of 1889 adopted the following constitutional provision concerning irrigation:

> All flowing streams and natural water courses shall forever remain the property of the State for mining, irrigation, and manufacturing purposes.

The title to the streams, therefore, remains with the State, and the State retains an absolute control over their use by the people. The State engineer is made by the irrigation code the custodian of all waters within the State, and must so regulate their use that the greatest benefit to the greatest number of people may accrue from their use.

The right to water that any individual derives from the State through the State engineer's office is based upon beneficial use and is

appurtenant to the land benefited. No person, however, can gain control of more water than he uses beneficially, and therefore in order to obtain a right to the use of water he must not only make application, but must proceed diligently to put the water applied for to beneficial use. The water rights must be carefully guarded, since if irrigation is successful there is certain to be a desire ultimately to utilize more water than is available in the streams at ordinary stages.

The opportunities for power developments are very limited in the State, owing to the levelness of the land and the light fall of its streams. At not to exceed six places on the streams of the State has power been developed, and it is not practicable to utilize any other localities within the knowledge of the State engineer for this purpose.

The largest tributaries of the Missouri River in North Dakota are on the west side, and commencing at the south they are as follows: Cannon Ball, Little Heart, Heart, Square Butte, Knife, and Little Missouri. Cannon Ball River drains Adams and Hettinger counties, the southern part of Morton County, and the southeastern portion of Billings County. Exceptional opportunities are offered for the development of irrigation projects covering 100 to 5,000 acres. This river is about 160 miles long and has many small streams tributary to it. It is joined in township 131, range 85, by the South Fork, locally termed "The Cedar." The area drained by the river comprises 2,700,000 acres of very fertile land, which in seasons of abundant rainfall produces bountifully. However, it is not a territory on which the farmer can feel secure in raising small grains on account of the low mean annual rainfall. By irrigating a small portion, raising alfalfa, and pasturing his rough land he is sure, however, to reap a good reward for his labor. The valleys proper of both the North Fork and the Cedar vary from a few hundred feet to a mile wide and are about 15 feet above the river. The land outside the valleys rises in benches of 100 to 300 feet above the stream. These benches are not continuous and the location of extensive irrigation canals is impracticable. Cut banks occur quite frequently and are of such material that the construction of ditches is an expensive undertaking. The irrigation of the benches above the valleys can best be accomplished by lifting water with centrifugal pumps, lignite coal being conveniently obtained. The grade of this stream averages 5 feet per mile. The flow, like that of all Dakota streams, is spasmodic. Its flow during the spring months, as will be noted by the stream measurements shown on page 14, is several hundred times that of July, August, and September. An occasional season occurs in which during these three months there is no perceptible flow and the water in the river is nothing but a series of standing pools. The opportunities for irrigation in the valley proper are many, but to be certain of water for more than a spring flooding the construction of reser-

voirs must be resorted to. The topography of the valley is such that good reservoir sites can be obtained which will store the entire annual flow.

Two miles above the mouth of Cannon Ball River, Chanta Peta Creek enters from the north and drains an area of 50,000 acres. There is 2,000 acres of bottom land along this creek which can be spring flooded easily. Dogtooth Creek, which enters in township 134, range 82, drains an area of 215,000 acres and has very good bottom lands convenient for irrigation. It must be admitted, however, that unless the construction of reservoirs is undertaken the irrigation of these bottoms must be done by the spring-flooding method. Thirty Mile Creek, which enters in township 133, range 91, is fed by springs, and during the summer months does not go entirely dry, as do many of the tributaries of the Cannon Ball. It drains an area of 160,000 acres. Philbrick Creek, which enters in township 136, range 98, is the most westerly tributary of any importance and drains an area of 90,000 acres. It has somewhat less irrigable land than the other tributaries, but what it has lies well for irrigation.

Cedar Creek, which joins the main stream in township 131, range 85, has a drainage area of 1,100,000 acres, being the largest tributary to the main stream. It has many fine bottom lands suitable for irrigation, either by the construction of reservoirs or by spring flooding. Timber Creek, which enters the Cedar in township 130, range 90, has a drainage area of 115,000 acres. It has a less fall per mile than any of the other tributaries of the Cedar and much more irrigable land is found along its course than can possibly be irrigated with the storage of the entire annual flow. Another Chanta Peta Creek enters the Cedar in township 132, range 96, with a drainage area about equal to the drainage area of Timber Creek. It drains an area, however, that is more rugged, and consequently has less irrigable land. It has good opportunities for the storage of the flood waters, and with a run-off greater than that of most of the other tributaries, these reservoirs can be made of much value in the storage of water for use on the Cedar.

Another stream of considerable importance in the development of irrigation in the State is the North Fork of the Grand River. While not a tributary of the Missouri in North Dakota, it drains an area of 375,000 acres in Bowman County, N. Dak., and Butte County, S. Dak. It takes its rise in the Bad Lands of North and South Dakota, flows parallel to the State line, and leaves the State in township 129, range 98.

The fall of the valley is 9 feet per mile, and owing to the rugged character of the lands in the drainage basin the run-off per mile is more than in many of our western streams. Along this stream in North Dakota, from township 129, range 101, to township 129, range

98, there is about 10,000 acres of very good land which lies along the valley of the stream from 12 to 15 feet above ordinary low water and varies from 0.5 to 1 mile in width. A reservoir of 18,000 acre-feet capacity can be secured in township 129, range 101, by the construction of a dam between ranges 100 and 101. The lands along the stream lie about equally on either side. A few cut banks are encountered, but are not of enough account to increase very materially the cost of construction of ditches or flumes for the conveyance of water in the main canals. Alkali land is found in small quantities, but not of such character that it can not be readily reclaimed by irrigation. Some sloughs near the west end of the tract and old channels of the stream are to be found, but in general the land lies well for irrigation. Lightning Creek, which enters the North Fork of the Grand River in township 129, range 98, has several small tracts of good land that can be irrigated by the construction of a reservoir. Buffalo Creek enters the North Fork of the Grand in South Dakota, but drains 100,000 acres in North Dakota. It has fine bottom lands along its entire course, but the opportunities for storage at a reasonable expense can not be found.

The Little Heart, a stream flowing into the Missouri in township 137, range 80, forms the next drainage basin of any account north of the Cannon Ball. This stream drains 150,000 acres of very fertile land having many fine flats susceptible of irrigation. Several storage sites are to be found near its headwaters, but owing to the small size of the drainage area where these reservoir sites are located, irrigation must be practiced in small tracts instead of in one large area. One of the oldest farming communities west of the Missouri River in this State is in this drainage area. Many fine buildings and well-farmed lands are to be found here and the farmers are numbered among the most prosperous in North Dakota.

Next in order north of the Little Heart is the Heart River, a stream rising in the eastern edge of the Bad Lands and consequently about the length of the Cannon Ball. It has a drainage area of 2,150,000 acres, draining the middle eastern portion of Billings County, practically all of Stark County, and the northern half of Morton County. The main line of the Northern Pacific Railroad follows the valley of this stream for 50 miles and for 70 miles more is within its drainage basin. The fall of this stream is about 6 feet per mile. Mandan, an important town on the Northern Pacific, is situated on the Missouri River near the mouth of this stream, and Bismarck, the capital of the State, is situated directly opposite on the east side of the Missouri. The principal tributaries of Heart River in their order from its mouth to its source are Sweet Briar, which comes in from the north, in township 139, range 82, and has a drainage area of 160,000 acres and irrigable land 10 to 20 feet above the creek bed to the extent of

10,000 acres; Curlew Creek, which comes in from the north also, in township 136, range 85, drains an area of 300,000 acres, has at least 25,000 acres of irrigable land lying about 20 feet above the bed of the stream, and has lignite coal in abundance along its entire course; Antelope Creek, coming from the south, in township 136, range 87, and draining an area of 125,000 acres; a second Antelope Creek, which, like the former, comes in from the southwest and drains an area of 170,000 acres. This latter stream has abundant opportunities for storing water which can be used for irrigation along its bottom lands and also along the bottoms of the main stream. The Northern Pacific follows closely the valley of the main stream from Gladstone to its source. Dickinson, an important division point of the railroad, is situated close to the river.

Green River, the last important tributary, drains an area of 160,000 acres, comes in at Gladstone, and offers exceptional opportunities for irrigation. The several private projects already in operation furnish sufficient proof that the irrigation of the bottom lands of Heart River produce crops exceeding 200 to 300 per cent the crops raised by dry-farming methods.

Next above Heart River, coming from the west, is the Square Butte Creek, draining an area of 155,000 acres and flowing into the Missouri in township 140, range 81. There are 15,000 acres of bottom lands along this creek which can be irrigated easily, and there is every reason to suppose that within the next ten years advantage will be taken of the numerous sites. This stream is about 30 miles long and has a fall per mile greater than any other one in the State west of the Missouri.

The next stream of importance which flows into the Missouri from the west is 50 miles up the river from Square Butte Creek, and is called "Knife River." This, like the Cannon Ball and Heart, takes its rise in the eastern ridge of the Bad Lands and drains an area of 1,600,000 acres, draining the northeastern portion of Billings County, the south half of Dunn County, nearly all of Mercer County, and the northwestern portion of Oliver County. There are more extensive opportunities for irrigation in the valley of this stream than on any other stream of its size in the State, likewise the opportunities for storage near its headwaters are extremely good. Including the flats on the Missouri River bottom at Stanton, there are 15,000 acres of irrigable land within 15 miles of its mouth.

Antelope Creek is the first important creek along Knife River west of the Missouri. This creek comes in from the north in township 144, range 86, drains an area of 70,000 acres, and offers several good opportunities for irrigation.

Spring Creek, coming from the northwest, enters in township 144, range 88, drains an area of 360,000 acres, and, as its name implies,

is fed by numerous springs. One of its branches which furnishes an abundant supply of splendid water at all seasons of the year takes its rise in Kildeer Mountains.

Elm Creek comes in from the south in township 142, range 90, has a drainage area of 60,000 acres and several thousand acres of irrigable land not to exceed 15 feet above its bed.

Little Knife River comes in from the south in township 142, range 91, and has a drainage area of 150,000 acres, with 10,000 acres of irrigable land not to exceed 20 feet above its bed.

Crooked Creek comes in from the south in township 142, range 94, and has a drainage area of 90,000 acres, and 4,000 acres of irrigable land from 10 to 20 feet above its bed. Lignite coal is found along the entire length of Knife River and its tributaries, thus insuring an abundance of fuel for the rancher and settler.

Little Missouri River is the largest tributary of the Missouri in North Dakota. It rises in northeastern Wyoming and flows north nearly parallel to the State line between Montana and North Dakota and 10 to 20 miles distant therefrom for a distance of 120 miles, then turns abruptly to the east and enters the Missouri. It drains an area of 6,000,000 acres, running through the Bad Lands for its entire distance.

As will be seen from a study of the stream gaugings, the flow of all the streams tributary to the Missouri is very irregular. There is first a heavy spring flood and a June rise. These soon subside, and the problem of irrigating to any great extent must be dependent upon the storage of the flood waters. Storage reservoirs can be constructed on all the main streams and branches at a cost that will not be prohibitive, and large areas which are now only partially productive thus made to yield much greater returns.

The streams of importance tributary to the Missouri on the east and north side drain a much smaller area than those tributary from the west. The area drained by these streams and the possibilities of irrigation from them is given in the following table:

Drainage areas and irrigation possibilities of the northern and eastern tributaries of the Missouri River in North Dakota.

Name of stream.	Drainage area.	Irrigation possibilities.
	Acres.	
Beaver Creek	384,000	Several thousand acres under irrigation. Some reservoir sites.
Long Lake Creek	160,000	Very little irrigable land.
Apple Creek	260,000	Storage opportunities limited.
Painted Woods Creek	230,000	Good storage opportunities, but water alkaline.
Shell Creek	175,000	(See Shell Creek pumping project, p. 26.)
Little Knife River	92,000	Several thousand acres under irrigation.
White Earth Creek		Considerable bottom land under irrigation.
Little Muddy Creek	525,000	Considerable spring flooding. Flows through Williston pumping project.

RIVER RECORDS FOR 1903–1908.

Gauging stations were established on the most important streams during the years 1901 to 1904 by the United States Geological Survey, and the summarized monthly flow of the measurements is shown in the table following. Where leaders are used in figure columns no records were obtainable.

Highest, lowest, and average mean discharge in cubic feet per second of North Dakota streams for each month, 1903–1908.

Rivers and place of measurement.	January.	February.	March.	April.	May.	June.
Red River at Grand Forks:						
Highest	.....	.....	[a] 4,600	[b] 32,900	16,640	11,240
Lowest	.....	.....	[a] 1,400	2,030	1,990	1,940
Average	1,368	[c] 1,207	[c] 2,114	[c] 2,114	7,612	5,744
Mouse River at Minot:						
Highest	.....	.....	[d] 108	1,320	2,660	2,590
Lowest	.....	.....	[d] 78	33	33	68
Average	[e] 11	[e] 9	[f] 42	[g] 246	[c] 486	[c] 399
Heart River at Richardtown:						
Highest	.....	.....	2,350	4,115	2,504	8,800
Lowest	.....	.....	[d] 16	2	0	4
Average	[h] 3	[h] 64	[f] 236	[c] 288	97	248
Knife River at Broncho:						
Highest	.....	.....	[i] 560	[c] 3,400	2,430	2,205
Lowest	.....	.....	[d] 14	[c] 4	4	4
Average	.....	.....	[a] 190	[c] 279	115	182
Cannon Ball River at Stevenson:						
Highest	.....	3,580	[f] 3,800	[c] 3,720	[c] 2,620	5,350
Lowest	.....	.....	[d] 98	[c] 5	[c] 4	3
Average	[e] 4	[f] 772	[f] 643	[c] 467	[c] 326	833
Little Missouri River at Medora:						
Highest	.....	[h] 8,100	7,200	3,890	15,500	[c] 19,000
Lowest	.....	.....	41	[c] 4	4	[c] 16
Average	[h] 40	[h] 1,650	941	466	869	[c] 2,235
Little Muddy at Williston:						
Highest	.....	.....	[d] 200	[c] 3,000	[c] 700	[c] 1,570
Lowest	.....	.....	[d] 16	6	10	10
Average	.....	.....	[i] 34	466	60	71

Rivers and place of measurement.	July.	August.	September.[a]	October. (a)	November.[a]	December.[a]
Red River at Grand Forks:						
Highest	6,860	10,850	5,240	4,200	3,330	[h] 1,500
Lowest	1,067	870	1,470	1,395	1,330	[h] 1,100
Average	3,765	2,806	2,534	2,533	2,071	1,502
Mouse River at Minot:						
Highest	878	248	1,134	509	191	.....
Lowest	59	31	10	8	16	.....
Average	231	105	574	84	[c] 31	[k] 13
Heart River at Richardtown:						
Highest	643	530	336	13	11	.....
Lowest	0	0	2	2	2	.....
Average	50	9	14	4	6	[k] 3
Knife River at Broncho:						
Highest	2,030	311	217	14	[l] 13	.....
Lowest	4	1	2	2	[l] 2	.....
Average	43	17	17	7	[m] 8	.....
Cannon Ball River at Stevenson:						
Highest	1,130	2,040	1,270	107	[o] 63	.....
Lowest	2	0	[n] 0	[n] 0	[o] 0	.....
Average	153	98	61	14	[p] 19	[k] 4
Little Missouri River at Medora:						
Highest	7,500	6,100	5,550	681	101	.....
Lowest	27	5	2	2	10	.....
Average	1,175	747	422	84	76	[q] 50
Little Muddy at Williston:						
Highest	35	14	13	16	[r] 16	.....
Lowest	6	4	6	6	[r] 9	.....
Average	11	7	6	10	12	.....

[a] No records before 1908.
[b] Record for only fifteen days.
[c] No record for 1903.
[d] Record of 1905 only.
[e] From records of 1907 and 1908.
[f] From records of 1905, 1907, and 1908.
[g] No records for 1903 or 1904.
[h] Record for 1907 only.
[i] From records of 1905 and 1908.
[j] No records for 1908.
[k] From records of 1906 and 1907.
[l] From records of 1903 and 1905.
[m] From records of 1903, 1905, and 1906.
[n] No records for 1905.
[o] No records for 1904 and 1906.
[p] No records for 1904.
[q] No records for 1906.
[r] From records of 1904, 1905, and 1906.

LANDS.

It is conceded by all who are familiar with the State of North Dakota that there is a large amount of arable land in the State and that the relative fertility of the soil is very high. Doctor Leonard, the State geologist, reports on the soils of the State as follows:

SOIL FORMED OF LAKE SEDIMENTS.

Some of the richest and most productive soils in North Dakota are composed of the sediments laid down in old glacial lakes. The largest of these occupied what is now known as the "Red River Valley." The rivers flowing into it brought their loads of mud and sand and these materials were distributed over the bottom of the lake by the waves and currents. Thus were formed the rich soils of Richland, Cass, Traill, Grand Forks, Walsh, and Pembina counties, composed of lacustrine silt and containing fine sand, clay, powdered limestone, and carbonaceous matter.

In some localities they are quite sandy, in others they form a rather tough clay or gumbo, while in still others they are a sandy clay or loam.

Lacustrine soils were also formed in a smaller glacial lake which lay south and west of the Turtle Mountains. It extended west and south as far as Minot and Velva, east as far as Rugby, and north across the international boundary into Manitoba. The soils formed on the bottom of this lake thus cover the greater part of Bottineau and McHenry and adjoining portions of Rolette, Pierce, and Ward counties.

GLACIAL DRIFT SOILS.

These cover by far the larger part of the State and are the result of the work of the great ice sheet which once occupied the region. * * * When after some hundreds or thousands of years the glacier melted and disappeared, it left a deposit of clay, sand, gravel, and bowlders which form a mantle covering the bed rock. To this heterogenous material left by the ice the name "drift" is applied. It varies in thickness from a foot and less to several hundred feet. The drift underlies the lacustrine deposits of the Red River Valley and the Mouse River country, and forms the soil of the remaining portions of the State with the exception of the southwestern corner, where the drift is absent.

These soils are formed in large part of materials derived from the underlying bed rock, but mingled with this material is rock flour and coarser particles and fragments ground from the surface over which the glacier moved and transported often long distances. The ingredients of the North Dakota drift are many of them derived from the limestones and granite rocks of Manitoba. The fertility of many of the drift soils is due to the fact that they contain the constituents of plant food—the lime, potash, and other salts—in the proper proportion and have also been enriched by decayed vegetation.

RESIDUAL SOILS.

These are confined to the southwestern corner of the State, where they occur in Billings, Bowman, Adams, Hettinger, and Stark counties, as well as in parts of adjoining counties. The rocks of this region are chiefly clays, sandstones, and shale, and the soils are formed by the disintegration of these rocks. They are therefore usually composed of a mixture, in varying proportions of sand and clay mingled with organic matter from the vegetation. The

soils of Oliver, Mercer, McKenzie, and portions of Dunn and Morton counties, are in part drift soils and in part residual. Some of their materials have been transported a greater or less distance by the continental glacier, while some have been derived from the rock on which they rest.

ALLUVIAL SOILS.

These are found along the rivers and constitute soils of great fertility. The alluvium occurs on the lowlands or flood plains forming the bottoms of the valleys, and is seldom more than 20 or 30 feet above the river level. The alluvial material consists of sand or clay, or a mixture of the two, and represents the sediment laid down by the streams in the time of flood. All of the larger rivers of the State have developed flood plains varying in width from a fraction of a mile to several miles and formed of alluvial deposits, which constitute the rich soil of bottom lands.

CLASSIFICATION OF LANDS AS TO PRODUCTIVENESS.

No previous recorded attempt has been made to classify the 44,800,000 acres in the State into arable, irrigable, grazing, forest, and waste lands, and any attempt to make such classification must necessarily entail a great amount of study. However, with the data which the State engineer has accumulated from his extensive acquaintance with the State an estimate can be given which approximates closely to the correct quantities. If in estimating the area of arable land in the State one looks into the future and considers the advances that are being made in agricultural methods, it can readily be foreseen that land which at present is not considered of sufficient value to be cultivated will within the next generation be valuable as cultivated land. With this understanding, it is estimated that the area of arable land is 42,150,000 acres; irrigable land, 1,540,000; grazing land, 2,500,000; waste land, 150,000; and forest land, 500,000 acres.

There are no forest reserves in the State, but investigations and recommendations have been made which it is believed will lead to the creation of forest reserves amounting to 50,000 acres along the Little Missouri River. As noted from the above, the total area of forest land is small, the largest tracts being in the Turtle Mountains and along the Missouri and Little Missouri rivers. The forest lands in nearly all cases are grazing lands as well, for the reason that the forests consist of scattered growths of cottonwood, box elder, burr oak, cedar, elm, poplar, and similar trees

As shown by the statements above, the area of the waste land of the State is very small. The area of alkali land is very limited, and in most instances when it does occur it is of such a nature that it can be reclaimed without undue expense. The waste land is mostly found in the Bad Lands along the Little Missouri in the form of barren buttes and ravines which are being continually worked by the action of the elements.

A glance at the precipitation records (p. 7), shows the eastern half of the State has sufficient moisture for the production of good crops. This is true since the larger part of the rainfall is during the growing period. Since this portion of the State has a very slight fall drainage will be of benefit to a considerable amount of the land. Much of the land needing drainage is, however, being cultivated, and in the years of light rainfall during the growing season is producing good crops. Below is given a summary of the lands by counties within the State needing drainage, the irrigable acreages, and the acres under irrigation or in preparation for irrigation:

Lands drained, needing drainage, irrigated, and irrigable, by counties.

County.	Needing drainage.	Now drained.	Irrigable.	Irrigated or in preparation for irrigation.	County.	Needing drainage.	Now drained.	Irrigable.	Irrigated or in preparation for irrigation.
	Acres.	*Acres.*	*Acres.*	*Acres.*		*Acres.*	*Acres.*	*Acres.*	*Acres.*
Adams			30,000		McLean	25,000		150,000	
Barnes	250,000	15,000			Mercer			50,000	
Benson	50,000		10,000		Morton			200,000	
Billings			150,000	500	Nelson	50,000			
Bowman			35,000	1,000	Oliver			35,000	
Bottineau	60,000		50,000		Pembina	400,000	100,000		
Burleigh	25,000		75,000	500	Pierce	25,000		15,000	
Cass	375,000	125,000			Ramsay	75,000			
Cavalier	150,000				Ransom	75,000	10,000		
Dickey	35,000		10,000		Richland	125,000	75,000		
Dunn			55,000		Rolette	40,000		30,000	
Eddy	25,000		10,000		Sargent	140,000	25,000		
Emmons	15,000		45,000	300	Stark			35,000	
Foster	25,000		5,000		Steele	50,000	2,000		
Grand Forks	290,000	30,000			Stutsman	75,000		15,000	
Griggs	50,000				Towner	50,000		15,000	
Hettinger			35,000		Traill	250,000	20,000		
Kidder	50,000		10,000		Walsh	195,000	30,000		
La Moure	35,000		10,000		Ward	50,000		175,000	5,000
Logan	40,000		10,000		Wells	40,000		15,000	
McHenry	35,000		30,000		Williams	50,000		75,000	35,000
McIntosh	30,000		10,000						
McKenzie			150,000	22,000	Total	3,255,000	432,000	1,540,000	64,000

Aside from the United States Reclamation Service projects, the irrigated lands, as shown in the foregoing table, are mostly irrigated by a single spring flooding, and it has been found that every year lands so flooded produce bountifully. Better results could be obtained, however, if the water could be applied at the proper time.

PRODUCTS OF IRRIGATED LANDS.

At present the principal crops grown under irrigation in North Dakota are wheat, oats, barley, alfalfa, flax, potatoes, and all kinds of garden truck. That sugar beets of good quality can be profitably grown is no longer a question. The long days of sunshine during the growing season in the part of the State where irrigation is possible are particularly desirable for the production of a large quantity of

saccharine matter in this crop. Since this section is but 5° north of the sugar-beet fields of Michigan and Wisconsin and has a soil more fertile and a larger percentage of clear, sunny weather, it is believed by those familiar with beet-sugar production and manufacture that the western part of the State is destined to become a large producer of beet sugar. The following table, prepared from data reported by the United States Weather Bureau, gives the mean monthly and annual sunshine at Bismarck:

Sunshine at Bismarck.

Month.	Per cent.	Month.	Per cent.
January	60	August	67
February	60	September	68
March	50	October	65
April	61	November	53
May	53	December	54
June	58		
July	70	Annual	60

As previously stated, the most of the irrigation practiced heretofore has been by the spring-flooding method. The portion of the State benefited by irrigation has been occupied until recent years by stock growers. Those who practiced irrigation did so to secure a greater production of wild hay, and not until recent years, when with the influx of settlers restricting their range land and the extension of the branch lines of railroads giving easy access to markets, did they come to realize the great value of intensified farming. To show the value of the available water supply of the numerous creeks and coulées [a] for use in irrigation, the following quotation is given from a letter written by H. A. Nelson, of Ray, N. Dak., who has been practicing irrigation by the spring-flooding method since 1887:

During my residence in this valley (Nesson Valley) for twenty years I have discovered that the rainfall during the crop season has not been sufficient to produce an agricultural crop that would support the tiller of the land without the assistance of additional moisture supplied by some form of irrigation, and to substantiate the above statement will give my experience in growing crops during some of the crop seasons in the past twenty years.

In 1889 the soil was in fine condition for seeding, owing to the moisture which it received during the season previous (1888), and the weather was very favorable for growth of early sown grain. All grain sown and grass made a rapid growth during May, as there was a good fall of moisture during the entire month. The early part of June was also very favorable for the growth, as there was plenty of rain, but after June 10, until the last day of August or early in September, there was a marked scarcity of moisture, and all grain sown on land not supplied with additional moisture was an entire failure, and no hay was cut, except on land that had been irrigated.

[a] The word "coulée" is here used in the local sense.

But all land that was irrigated during the early spring and May and June of 1899 produced a good yield of wheat, oats, potatoes, corn, vegetables, and hay. The yields of grain, hay, and other produce during this crop season were as follows:

	Bushels.
Wheat, No. 1 hard	31
Oats, No. 1	68
Potatoes, lot 1	180
Potatoes, lot 2, supplied with additional moisture on July 10	360

Hay, about 2 tons per acre—bluestem or bluegrass.

The land that produced the above-named yields was irrigated or flooded with water during the last days of March, as the ground was free from frost and took the water readily, the ground being filled with water to a depth of 3 to 6 feet. The subsoil is very firm and hard when a depth of about 7 feet is reached, and the water does not leak away, but remains in the soil until drawn on to supply the moisture to growing plants when most needed.

I had no way of knowing how much water was supplied per acre, but believe not less than 12 inches. Some parts of the field got more water than others, and this was very noticeable during July of this season (1889), as the rainfall was of no benefit—only one small shower of three minutes' duration—but the part of the field getting the greatest amount of water was where the heaviest grain was grown; not so much difference in the straw, but quality and weight of grain, as the more water supplied the heavier the grain per bushel. This has always been my experience during other crop seasons.

The year 1892 was one of the best years, in my estimation, for the growth of grain, hay, and vegetables without the assistance of additional moisture. The rainfall of April was considerable and placed the surface soil in prime condition to germinate the seed. May, following with very warm weather, caused a good and rapid growth to be made, giving all grain and grass a good start. June came in with more rain and warm, favorable weather. This was followed by July, with more rain than in June, but very warm weather. To a nonresident it would seem that the rainfall had been sufficient to produce a No. 1 crop, but in this locality the moisture evaporates so rapidly during warm weather that the moisture the soil receives from falling rains is not long retained. It becomes necessary to supply the soil with enough moisture at one time to sink deep in the soil, where it remains until drawn on by vegetation.

The following table shows the yields of various crops upon the irrigated lands and upon the unirrigated tracts adjoining for the year 1892:

Crop.	Irrigated per acre.	Unirrigated per acre.
Wheat	32½ bushels No. 1	22 bushels.
Oats	78 bushels No. 1	38 bushels.
Hay	2–3 tons	¾ to 1½ tons.
Potatoes	190 bushels[a]	90 bushels.
Cabbage	38-pound heads	5 to 8 pound heads.

[a] But one flooding.

This yield upon unflooded or nonirrigated lands was the best of any during my entire residence in the Nesson Valley. The irrigated meadow lands above received an additional flooding during the last days of June and the growth was noticeably increased.

In conclusion, will say that the only successful way to farm lands in this locality is by the use of additional moisture when possible to supply the same.

I have worked along this line each and every year during my residence here, and in conclusion will state that it is my belief, based upon my own experience in growing grain, hay, and other agricultural produce, that land flooded in early spring (this is the way I supply most of the moisture used) will produce 200 and 300 per cent more than lands not so flooded.

Mr. Nelson has dammed a small creek, called "Nelson Creek," which is about 12 miles long and drains an area of 60,000 acres, and by taking all the spring flood has flooded about 1,200 acres. He has stated to the writer that could he have all the water he needed at the time needed he feels certain of an average production of 40 bushels of wheat, 90 bushels of oats, and 5 tons of alfalfa per acre, and other crops in proportion.

HISTORY OF IRRIGATION DEVELOPMENT IN NORTH DAKOTA.

The first steps taken to attract public attention to the value of irrigation in the western part of the State was the holding of a convention in Grand Forks in 1889, at which a memorial was prepared asking Congress to take steps preliminary to the construction of a canal from the Missouri River in Montana eastward through Montana and North Dakota to the Red River. The convention also adopted resolutions urging Congress to give the settled regions first attention rather than the unsettled sections.

In 1891 the office of superintendent of irrigation and forestry was created, and W. W. Barrett was made superintendent. Although provided with only a small appropriation, the money was well expended, and the reports, issued annually, contain very valuable information. But owing to the facts that little was known of irrigation throughout the Western States at this time and that the western part of North Dakota was but sparsely settled, and that only by stock growers, little interest was shown, and so little encouragement was given the superintendent that the legislature of 1901 abolished the office. However, since the passage by Congress of the Reclamation Act, under which act North Dakota was made one of the beneficiaries, considerable enthusiasm has been manifest throughout the State, and in October, 1903, the first State irrigation congress was held at Bismarck and the North Dakota Irrigation Association was formed. This association has been active in helping to secure for the State the Williston and the Buford-Trenton projects.

In the summer of 1904 a number of prominent citizens of the State advanced the sum of $5,000 to pay the salary and expenses of Prof. E. F. Chandler, of the University of North Dakota, to act as State irrigation engineer and to assist in bringing to the attention of the Reclamation Service the irrigable tracts of land in the State. Professor Chandler made a reconnaissance of all the main streams tribu-

tary to the Missouri River in the West, and his report to the governor and the legislature of 1905 is of great value to the State engineer's office and has assisted very materially in bringing about the passage of the irrigation code by the legislature. The code provided for the creation of the office of State engineer, with a term of office of four years. A. L. Fellows, of Denver, Colo., was appointed to fill the position, and on June 1 the appointment of T. R. Atkinson as assistant State engineer was confirmed by the governor. Mr. Fellows held the office of State engineer until July 1, 1907, when he resigned, and his assistant was made State engineer.

After the passage of the National Reclamation Act, and subsequent to the passage of an irrigation code by the State legislature, engineers of the Reclamation Service were active in investigating conditions in the State. Preliminary surveys were made on a Mouse River project and upon a project in the southwestern part of the State, on the Little Missouri, but neither of these was considered feasible at that time. Final surveys were made, however, on the Bismarck project, which contemplated the lifting of water from the Missouri River by pumps, the power being furnished by lignite coal. This project was abandoned by the Reclamation Service owing to the fact that since the land was nearly all in private ownership it was necessary to form a water users' association, and the necessary subscriptions to the stock of the association could not be secured.

Final surveys were made on the Williston and the Buford-Trenton projects and construction commenced in 1905. Water was applied to part of the land under these two projects during the season of 1908. It is thought now that irrigation on the other tracts will go forward at a very rapid rate. The construction of these larger projects has been an object lesson to the farmers in the semiarid parts of the State and will encourage the practice of irrigation on many small tracts.

There is, however, a feeling among some of the inhabitants of the State that irrigation should not be agitated or encouraged for fear the State will be advertised as an arid one and the feeling go abroad that crops can not be produced without irrigation. The season of 1908 has proved that with a good dry-farming method there will be no crop failures in North Dakota, but it is also true that by utilizing what water can be secured the land will produce much larger returns.

IRRIGATION ENTERPRISES.

All of the irrigation enterprises in North Dakota of any magnitude have been undertaken by the United States Reclamation Service. There are no Carey Act projects or projects under private enterprise which furnish water to other lands than those of the ditch

proprietor. The following description of the projects under construction by the United States Reclamation Service is taken largely from its reports:

BUFORD-TRENTON PROJECT.

One of the first projects to be undertaken by the Reclamation Service was the Buford-Trenton, situated on the north bank of the Missouri River in Williams County. This project includes the bench and bottom lands extending eastward along the left bank of the Missouri River about 15 miles from the State line between North Dakota and Montana. The Great Northern Railway skirts the northern limits. It comprises two distinct areas—the western, called the "Buford Flat," containing about 12,500 acres of irrigable land, and the eastern, called the "Trenton Flat," containing about 3,000 acres of irrigable land. No work has been done on the latter. On the former, canals and structures have been completed on the first unit of 4,333 acres and pumping machinery purchased and installed for about 12,000 acres.

The water is supplied from the Missouri River, being lifted 30 feet by centrifugal pumps located on a floating barge, and a further lift of 50 feet by centrifugal pumps located on the main canal. Power is supplied from the power plant at Williston, being transmitted 25 miles by electricity.

Under date of April 8, 1908, the Secretary of the Interior approved the public notice opening the first unit of the Buford-Trenton project, containing the following irrigable acreage:

	Acres.
Farm units	555
Private lands, subscribed	2,773
Private lands, not subscribed	649
State school lands	171
Government reservations	185
Total	4,333

The charges on each irrigable acre are divided into—

(1) A building charge of $38, payable in not less than five nor more than ten annual installments, each not less than $3.80 per acre.

(2) A fixed annual operation and maintenance charge of 70 cents, whether water is used or not.

(3) An additional charge for operation and maintenance of 50 cents per acre-foot for water actually pumped and delivered for irrigation in any year.

The charge of $4.50 covering building, fixed operation, and maintenance is due and payable May 1, 1909. The amount of water to be furnished is 2 acre-feet per acre per annum. The size of the farm units on this project is 160 acres.

WILLISTON PROJECT.

The Williston project is located in Williams County, on the left bank of the Missouri River. The portion of this project selected for initial development includes about 12,000 acres of irrigable land situated north, east, and west of the city of Williston. The water supply is pumped from the Missouri River by centrifugal pumps placed on a barge, the electric power being transmitted from a power house 4 miles up the Little Muddy Creek. The fuel used is lignite coal, mined by the Reclamation Service on Government land. This power plant also furnishes power for the Buford-Trenton project.

About 8,500 acres, lying north of the Great Northern Railway tracks and extending up the valley of the Little Muddy about 10 miles, is covered by the canal system now built. The remainder is situated in the river bottoms, which are now largely covered with brush and timber. No construction work has been started yet on the canal system for the bottom lands. Formal opening of the first unit of the project was made by public notice dated April 27, 1908. The approved farm-unit plats cover 7,943 acres of private lands, 160 acres of farm units open for entry, and 389 acres of Government reserves and school lands. The private lands covered by stock subscriptions in the Williston Water Users' Association amount to 6,101 acres, mostly in 160-acre tracts. The charges for construction, maintenance, and operation are the same as on the Buford-Trenton project.

LOWER YELLOWSTONE PROJECT.

This project includes about 60,000 acres along the east side of the Yellowstone River, 22,000 acres of which is situated in McKenzie County, N. Dak. Water for this project is obtained from the Yellowstone River by means of a diversion dam located 20 miles below Glendive, Mont.

The Northern Pacific Railway Company has located a line from Mandan, N. Dak., up the Missouri River to the mouth of the Yellowstone, and thence up the Yellowstone on the irrigated side. It is expected that this line will be constructed in 1909. Land under the Yellowstone project will be supplied with water for irrigation in 1909.

NESSON PROJECT.

The area covered by the Nesson project consists of bench land situated about 30 miles east of Williston, the larger part being on the north side of the Missouri River. The major part is in two benches, both of which are fairly smooth and have good drainage toward the river. A few creeks run into or through this territory. The lower bench covers about 6,500 acres and the upper bench about

12,000; the bench on the south side of the river covers about 4,000 acres. On the lower benches, on both sides, there is some brush and timber land which may possibly be excluded from the project. The rest is either under cultivation or is fine grass land.

As in the other projects, it was proposed to use the run-off of the various creeks adjacent to the land. This idea has been abandoned, owing to the small amount of water which can be obtained from this source, and the supply will be pumped from the Missouri River. The main pumping and power plant will be located in the western edge of the area and water delivered from here to the low-line canal, and probably to the two high-line canals. About 5 miles east of this point another pumping plant will be erected to lift water to two intermediate canals. The proposed lifts are approximately 30, 60, 80, and 105 feet. Coal for this project is found about 3 miles northwest of the power plant in 8-foot to 11-foot veins, on Government land. For the land south of the river a pumping plant will be constructed and electric power transmitted to it from the main plant. The lift will be 34 feet. A water users' association has been formed and incorporated, but the contract for the construction has not been made with the Secretary of the Interior.

BISMARCK PROJECT.

The district to be irrigated under the Bismarck project is near Bismarck, in township 138 north, range 80 west. The Northern Pacific Railway bridge crosses the Missouri River 1.5 miles west of the city. Here an extensive amount of work has been done in the past twenty years by the United States engineers and the railway company in building jetties and riprapping along the river banks to confine the river channel to one locality. Below the bridge for several miles the current of the river is toward the east bank. The riprapping extends along this bank from the bridge south for a distance of 1.5 miles. The site selected for the pumping plant by the Reclamation Service is within this stretch of the river. The protection of the river banks makes this location an ideal one for a pumping plant. The hills recede immediately east from this site, leaving a level bench of bottom land which contains approximately 7,000 acres, the half adjacent to the river being heavily timbered. This timbered area protects the open meadow from erosion by the river floods. Its general elevation is approximately 25 feet above extreme low water in the river. Adjoining this is a second bench known as the "Fort Lincoln" or "Post" bench, which contains approximately 3,500 acres and lies 25 feet higher. To the north and west, 25 feet higher yet, is a third bench, known as the "Penitentiary bench," containing approximately 3,500 acres. The second and third benches drain eastward

into Apple Creek, which in turn passes south of the second bench and through the lower end of the first bench into the Missouri River. The lower bench, with the exception of a small area in wheat, is given over entirely to the native hay crop. Owing to ice gorges in the river during the spring break-up this bench is flooded once in about twenty years. The soil is heavy and underlain with sand and gravel. In a few places along the upper edges of the bottom, where cultivated, it is very productive. The second and third benches are typical of the North Dakota prairie both as to soil and formation. The top soil is a heavy loam and very productive whenever the rainfall is sufficient. Probably one-half of this area is under cultivation, most of it being in wheat. Detailed surveys of this project were made in 1905, and a water users' association was formed, but owing to the inclination of some of the resident landowners to object to requirements of the Reclamation Service, construction of the project has not been commenced. It is very probable that another effort will soon be made to complete the water users' association and enter into an agreement with the Secretary of the Interior for the construction of the project.

FORT BERTHOLD INDIAN RESERVATION.

Fort Berthold Indian Reservation, containing 1,000,000 acres, lying between 47° 30′ and 48° north latitude, is divided into nearly equal parts by the Missouri River, which flows through it from the northwest to the southeast corner. Only nine townships of this reservation have been surveyed by the General Land Office, and these only for the purpose of making allotments to the Indians. Along the river through the reservation are several fine bottoms and adjoining bench lands which can be irrigated by pumping from the river. Realizing that it will only be a matter of a few years until this reservation will be opened to settlement, the State engineer has recently made preliminary surveys of the larger tracts in order that irrigation systems could be constructed prior to the opening of these lands.

Lignite coal in abundance is found along the whole course of the river through the reservation, and a party from the United States Geological Survey is making examinations for the purpose of determining the thickness of the veins and the quality of this coal, which is in close proximity to the several projects. A branch of the Northern Pacific has been located and the right of way purchased for a line north from Mandan, following closely the left bank until the Yellowstone is reached and up the right bank of the Yellowstone to a junction with the main line at Glendive. This line will undoubtedly be in operation within two years and will make the projects on the west side of the river more valuable.

SHELL CREEK PROJECT.

The Shell Creek project, preliminary surveys of which were made by the State engineer in October and November, 1907, is situated on the north side of the Missouri River on the Fort Berthold Indian Reservation. This project comprises 18,000 to 20,000 acres of irrigable land at a maximum elevation of 100 feet above low water in the Missouri River. Shell Creek, which drains an area of 175,000 acres, runs through the center of the project and the flow can be stored and utilized on several thousand acres. The soil is mostly sandy loam. Only small areas have been cultivated by the Indians, but when the rainfall is sufficient the soil has shown great fertility. The presence of lignite coal in large quantities is shown by outcrops. Under date of December 17, 1907, the State engineer made a report on this project to the Reclamation Service, and it is expected that the construction of this project will be undertaken within a few years.

INDEPENDENCE PROJECT.

Directly south from the Shell Creek project, on the right bank of the river, lies the Independence project. The soil is a sandy loam on the bottom and clayey loam on the first bench. There are 2,600 acres of grass land and 2,700 acres of brush land in this project. The maximum pumping lift to cover this amount of land will not exceed 80 feet. Independence Indian village lies on the eastern edge of this tract.

ELBOWOODS PROJECT.

Commencing near the north line of township 149, range 90, on the left bank of the Missouri River, is a series of bottoms and benches extending down the river 18 miles, consisting of 8,000 acres of grass land and 5,000 acres of timber and brush land, which can be reached by a maximum lift of not to exceed 100 feet. Elbowoods post-office and Fort Berthold Indian Agency are situated at the extreme southeastern edges of this project. Rising Water Creek, which empties into the river in section 18, township 149, range 90, has a drainage area of about 50,000 acres. The soil is sandy loam on the brush-covered bottoms and sandy loam and clayey loam on the benches.

FORT BERTHOLD PROJECT.

In this project is situated the original Government military post called "Fort Berthold." The project lies in township 147, ranges 87 and 88, and contains about 10,000 acres of irrigable land, 3,500 of which is brush and timber. The range line between ranges 87 and 88 is the east boundary line of the Fort Berthold Reservation. The soil is a sandy loam on the brush-covered bottoms and clayey loam on the benches.

The maximum pumping lift will be 90 feet, and lignite coal is found in close proximity to the proposed location of the main pumping plant.

STEVENSON PROJECT.

The old Fort Stevenson Military Reservation, which was sold to private purchasers in 1901 and has been acquired since by settlers, includes lands lying on both sides of the Missouri River in township 147, ranges 85 and 86. Of the land in these two townships, about 20,000 acres can be irrigated by a maximum pumping lift of 90 feet, 16,000 acres of which lies on the north side of the river and 4,000 acres on the south side. Of the total amount of irrigable land in this tract, 4,000 is now in brush and timber. Lignite coal in abundance is found on each side of the river convenient for use in a pumping project. The landowners under this project are very anxious to have the Reclamation Service undertake construction on this project, and it is expected that the initial steps necessary for the accomplishment will be commenced this fall.

HANCOCK PROJECT.

On the east side of the Missouri River, in townships 145 and 146, range 84, lies the Hancock bottoms, comprising about 7,000 acres, which lies well for irrigating by pumping, the maximum lift being 80 feet. These bottoms have been settled for about thirty years, yet a very small portion of the tract has been broken, the settlers having confined their efforts to ranging live stock. Now the range country is being settled rapidly and the landowners on the bottoms desire irrigation in order to assist them in their agricultural efforts. Lignite coal is convenient for fuel, and the construction work on this project will probably go forward within a very few years.

WASHBURN PROJECT.

The Washburn project lies on the left bank of the river, in townships 142, 143, and 144, range 81, and includes the Painted Woods bottoms. In this project there will be about 10,000 acres of irrigable land at a maximum pumping lift of 80 feet. Turtle and Painted Woods creeks empty into Painted Woods Lake, which lie in the bottom close to the Missouri River. The Bismarck-Minot branch of the "Soo" line cuts across the north and east edges of this project. A water-users' association has been formed, and 90 per cent of the landowners have joined it. Detail surveys, under charge of George E. Stratton, project engineer, have been underway since the 1st of August, and it is expected that the construction work will be started in 1909.

OLIVER PROJECT.

On the right bank of the river in Oliver County there is about 7,000 acres, and the majority of the landowners have signed an agreement to take stock in a water-users' association. The proposed new branch of the Northern Pacific skirts the western edge of this project.

Preliminary surveys are now being made by the Reclamation Service, and it is expected that the construction of this project will go forward at the same time as that of the Washburn project.

BOWMAN PROJECT.

Among the few good gravity projects in North Dakota one of the most promising is in Bowman County, along the North Fork of the Grand River. This stream follows close to the State line through township 129, ranges 98, 99, and 100. Preliminary surveys of this project were made by the State engineer's office in 1906. With a dam near the line between ranges 100 and 101, with a maximum height of 41 feet and an extreme length of 3,800 feet on top, a reservoir of 18,000 acre-feet can be created. It is estimated that 10,000 acres can be irrigated along this valley, about one-third of which will be in South Dakota. A party from the Reclamation Service, under W. A. Stebbins, is now engaged upon the detail surveys.

There are several other pumping projects along the Missouri River bottoms, of which preliminary surveys will be made by the State engineer's office at an early date. It is estimated that there is a total of 250,000 acres of irrigable land along the Missouri River which can be irrigated by pumping lifts not exceeding 100 feet.

LAWS GOVERNING THE CONTROL AND USE OF WATER IN NORTH DAKOTA.

The irrigation code adopted by the legislature of 1905 is practically identical with that of several Western States. In so far as it relates to applications for water rights it is as follows:

FEES OF STATE ENGINEER.

SEC. 10. The State engineer shall receive the following fees, to be collected in advance and to be paid by him into the general fund of the State treasury on the last day of March, June, September, and December of each year:

(*a*) For filing and examining an application for permit to appropriate water, map, and field notes of the same, $5.

(*b*) For recording any permit, certificate of construction, or license issued, or any other water-right instrument, $1 for the first hundred words and 15 cents for each additional hundred words or fraction thereof.

(*c*) For filing any other paper, $1.

(*d*) For issuing certificates of construction or license to appropriate water, $1 each.

(*e*) For making copy of any document recorded or filed in his office, 15 cents for each hundred words or fraction thereof.

(*f*) For blueprint copy of any map or drawing, 10 cents per square foot or fraction thereof. For other copies of drawings, actual cost of the work.

(*g*) For certifying to such copies, $1 for each certificate.

(*h*) For examining and approving in connection with water-right applications plans and specifications for any dam not exceeding 10 feet in extreme height from the foundation, $10; for a dam higher than 10 feet and not exceeding 30 feet, $20; for a dam higher than 30 feet and not exceeding 50 feet, $30; for a dam higher than 50 feet, $50; or for a canal or other water conduit of an estimated capacity exceeding 50 and not more than 100 cubic feet per second, $20; for an estimated capacity exceeding 100 cubic feet per second, $30.

(*i*) For inspecting dam sites and construction work when required by law, or when necessary in the judgment of the State engineer, $10 per day and actual and necessary traveling expenses. The fees for any inspection deemed necessary by the State engineer and not paid on demand shall be a lien on any land or other property of the owner of the works, and may be recovered by the State engineer in any court of competent jurisdiction.

(*j*) Rating ditches or inspecting plans and specifications of works for the diversion, storage, and carriage of water at the request of private parties, not in connection with an application for right to appropriate water, actual cost and expenses; and the State engineer shall attach his approval to such plans and specifications if found satisfactory.

(*k*) For such other work as may be required of his office, the fees provided by law.

(*l*) In ascertaining actual cost of any work, as the term is used in this section, the salary of any salaried officer for the time employed shall be included.

APPROPRIATION OF WATER.

SEC. 19. *Application for water rights.*—Any person, association, or corporation hereafter intending to acquire the right to the beneficial use of any waters, shall, before commencing any construction for such purpose or before taking the same from any constructed works, make an application to the State engineer for a permit to appropriate, in the form required by the rules and regulations established by him. Such rules and regulations shall, in addition to providing the form and manner of preparing and presenting the application, require the applicant to state all the data necessary for the proper description and limitation of the right applied for, as to the amount of water and periods of annual use, together with such information, maps, field notes, plans, and specifications as may be necessary to show the method and practicability of the construction and the ability of the applicant to complete the same. All such maps, field notes, plans, and specifications shall be made from actual surveys and measurements, and shall be retained in the office of the State engineer after the approval of the application. The State engineer may require additional information not provided for in the general rules and regulations in any case involving the diversion of 500 cubic feet of water per second, or more, or the construction of a dam more than 30 feet high from the foundation. The owners of works proposing to store or carry water in excess of their needs for beneficial use may make application for such excess, and shall be held as trustees of such right for the parties applying the water to a beneficial use; and shall be required to furnish the water for such parties at reasonable rates for storage, or carriage, or both, as the case may be.

SEC. 20. *Filing and correction of application.*—The date of receipt of such application in the State engineer's office shall be indorsed thereon and noted in his records. If the application is defective as to form or unsatisfactory as to feasibility or safety of plan, or as to the showing of the ability of the applicant to carry the construction to completion, it shall be returned, with a statement of the corrections, amendments, or changes required, within thirty days after its receipt, and sixty days shall be allowed for the refiling thereof. If refiled, corrected as required within such time, the application shall, upon being accepted, take priority as of date of its original filing, subject to compliance with the further provisions of the law and the regulations thereunder. Any corrected application filed after the time allowed shall be treated in all respects as an original application received on the date of its refiling: *Provided*, That the plans of the construction may be amended, with the approval of the State engineer, at any time; but no such change shall authorize any extension of time for construction beyond five years from the date of the permit, except as provided in section 30: *Provided further*, That a change in the proposed point of diversion of water from a stream shall be subject to the approval of the State engineer, and shall not be allowed to the detriment of the rights of others having valid claims to the use of water from said stream.

SEC. 21. *Publication of notice.*—Upon the filing of an application which complies with the provisions of this act and the rules and regulations established thereunder, the State engineer shall instruct the applicant to publish notice thereof, in a form prescribed by him, in some newspaper of general circulation in the stream system once a week for four consecutive weeks. Such notice shall give all essential facts as to the proposed appropriation, among them the places of appropriation and of use, amount of water, the purpose for which it is to be used, name and address of the applicant, and the time when the application will be taken up by the State engineer for consideration. Proof of publication, as required, shall be filed with the State engineer within sixty days from the date of his instructions to make publication. In case of failure to file satisfactory proof of publication in accordance with the rules and regulations applicable thereto, within the time required, the application shall thereafter be treated as an original application filed on the date of receipt of proofs of publication in proper form.

SEC. 22. *Approval of application.*—Upon the receipt of the proofs of publication, the State engineer shall determine, from the evidence presented by the parties interested, from such surveys of the water supply as may be available, and from the records, whether there is unappropriated water available for the benefit of the applicant. If so, he shall indorse his approval on the application, which shall thereupon become a permit to appropriate water, and shall state in such approval the time within which the construction shall be completed, not exceeding five years from the date of approval, and the time within which the water shall be applied to a beneficial use, not exceeding four years in addition thereto.

SEC. 23. *Rejection and appeal.*—If, in the opinion of the State engineer, there is no unappropriated water available, he shall reject such application. He shall decline to order the publication of notice of any application which does not comply with the requirements of the law and the rules and regulations thereunder. He may also refuse to consider or approve an application or to order the publication of notice thereof if, in his opinion, the approval thereof would be contrary to the public interest. Any applicant may appeal from such decision of the State engineer, or from any other decision by him which denies a substantial right, within sixty days from the date thereof, to the district court

of the county in which the proposed place of diversion or storage is situated. In the absence of such appeal the decision of the State engineer shall be final.

SEC. 24. *Prosecution of work.*—The construction of the works shall be diligently prosecuted to completion, and if one-fifth of the work shall not be completed within one-half the time allowed, the State engineer may accept and approve, as herein provided, an application for the use of all or any of the waters included in the permit issued to the prior applicant and the right to use such waters under the former permit shall thereupon be forfeited: *Provided*, That the State engineer shall allow an extension of time on request of the prior applicant equal to the time during which work was prevented by the operation of law, beyond the power of the said applicant to avoid.

SEC. 25. *Completion of work.*—On the date set for the completion of the work, or prior thereto, upon notice from the owner that the work has been completed, the State engineer shall cause the work to be inspected, after due notice to the owner of the permit. Such inspection shall be thorough and complete, in order to determine the actual capacity of the works, their safety, and efficiency. If not properly and safely constructed the State engineer may require the necessary changes to be made within a reasonable time, not to exceed six months, and shall not issue his certificate of completion until such changes are made. Failure to make such changes shall cause the postponement of the priority under the permit for such time as may elapse from the date for completing such changes until made to the satisfaction of the state engineer, and applications subsequent in time shall have the benefit of such postponement of priority: *Provided*, That for works involving the diversion of not exceeding 20 cubic feet per second of water or a dam not exceeding 10 feet in the extreme height from the foundation, the State engineer may, in his discretion, accept the report of an inspection by a reputable hydraulic engineer.

SEC. 26. *Certificate of completion.*—When the works are found in satisfactory condition, after inspection, the State engineer shall issue his certificate of construction, setting forth the actual capacity of the works and such limitations upon the water right as shall be warranted by the condition of the works, but in no manner extending the rights described in the permit.

SEC. 29. *Application to beneficial use.*—On or before the date set for the application of the water to a beneficial use the State engineer shall cause the works to be inspected, after due notice to the owner of the permit. Upon the completion of such inspections the State engineer shall issue a license to appropriate water to the extent and under the conditions of the actual application thereof to a beneficial use, but in no manner extending rights described in the permit: *Provided*, That the inspection to determine the amount of water applied to a beneficial use shall be made at the same time as that of the constructed work, if requested by the owner, and if such action is deemed proper by the State engineer.

SEC. 20. *Extension of time.*—The State engineer shall have power to extend the time for the completion of construction, or for application to beneficial use, for three years and two years, respectively, but only on account of delays due to physical or engineering difficulties which could not have been reasonably anticipated, or by operation of law beyond the power of applicant to avoid.

SEC. 31. *Assignment of permit or license.*—Any permit or license to appropriate water may be assigned, but no such assignment shall be binding, except upon the parties thereto, unless filed for record in the office of the state engineer. The evidence of the right to use water from any works constructed by the United States, or its duly authorized agencies, shall, in like manner, be filed in the office of the State engineer, upon assignment: *Provided*, That no

right to appropriate water for irrigation purposes shall be assigned, or the ownership thereof in any wise transferred, apart from the land to which it is appurtenant, except in the manner specially provided by law: *Provided, further,* That the transfer of title to land in any manner whatsoever shall carry with it all rights to the use of water appurtenant thereto for irrigation purposes.

EXPLANATION OF LAWS.

From a study of the provisions of the law cited above it will be seen that the various steps to be followed in making an appropriation of water for a beneficial use are as follows:

(1) *Application.*—Instructions and forms are first to be obtained from the State engineer. After the form has been filled out in detail, it is to be sent to the State engineer accompanied by $5 for each separate application. When required, fees to cover the charges authorized in paragraphs *h* and *i* of section 10 must also be sent to the State engineer before any decisive action will be taken by him. The State engineer will then examine the application, and if, in his opinion, the provisions of the law are not duly complied with, he will return the application for correction, informing the applicant concerning any additions or corrections that are to be made. The applicant should carefully study section 20, quoted above, since all its provisions must be complied with before the application can possibly be accepted.

(2) *Publication of notice.*—The State engineer will furnish the proper forms for notices when he issues the instructions, specifying the paper in which the notice is to be published, the applicant, however, stating his preference. A form for proof of publication will also be furnished to the applicant, which must be filled out and filed in the office of the State engineer within sixty days of the date of his instructions, as provided by law. The fee for filing this paper is $1.

(3) *Consideration of application.*—Upon the receipt of the proofs of publication, with fee for same, the State engineer will give his consideration to the application, and will decide, in view of all available evidence, whether the application should be accepted or rejected. If he concludes that it should be accepted, he will give it his provisional approval. He will then notify the applicant of such acceptance, informing him as to the fees necessary for recording, as this charge must be forwarded so as to reach the office of the State engineer within thirty days of such notification; and in this event the State engineer will record the application with his approval thereof in a book provided for the purpose, granting through this act a permit to construct the proposed works as above approved, this permit being given a permanent number, all permits in a single water division being numbered consecutively. He will then notify the applicant of his action, sending him the permit, thus authorizing him to proceed with the work of construction. If the fees required for making the record are not

received within thirty days, as provided for herein, the permit will not be recorded until such time as they are received, the right in that case not relating back to the time of application, but only to the time of the receipt of the fees.

The State engineer may reject an application, as provided in section 23, in case he decides that the proposed appropriation would be detrimental to the public welfare. In such case he will file the papers in the case, notifying the applicant of his action.

(4) *Due diligence.*—The work shall be diligently prosecuted, and prior to or upon the expiration of one-half of the entire time allowed in the permit the appropriator shall demonstrate to the satisfaction of the State engineer that one-fifth of the total amount of work has been done as required. Here, as in all other cases of failure to comply with the requirements of the law, if this amount of work is not completed the applicant may lose his priority. On or before the date set for the completion of the work the applicant shall likewise demonstrate that the work has been completed in accordance with the terms of the permit. When, for good and sufficient reasons, it has been impracticable to complete the work within the time limit fixed in the permit, such reasons should be stated in an affidavit to be filled with the State engineer. The proper forms will be furnished and all charges in accordance with section 10 must be paid upon demand. The fact should be borne in mind that the claim does not become an actual right until the water is actually and beneficially used, and a "license" therefor is issued, as provided in section 29, or the matter has been adjudicated by the district court.

(5) *Beneficial use.*—Section 29 explains fully the method of acquiring the right to appropriate water. Section 2 states specifically that "beneficial use shall be the basis, the measure, and the limit of the right to use water, and all waters appropriated for irrigation purposes shall be appurtenant to specified lands owned by the person claiming the right to use the water so long as the water can be beneficially used thereon. Priority in time shall give the better right."

INSTRUCTIONS TO PROSPECTIVE IRRIGATORS.

The following additional information and instructions should be carefully studied and followed:

(1) A complete copy of the irrigation laws will be furnished free to anyone making a request for the same to the State engineer. All forms needed will be similarly furnished also upon request.

(2) The State engineer can not engage in private practice, but suggestions and advice, so far as proper, will be gladly furnished. When the official services of the State engineer or of a deputy are required, such services and expenses in connection therewith must be paid for

by the applicant in accordance with the provisions of paragraphs *i*, *j*, *k*, and *l*, of section 10.

(3) Fees must accompany applications as provided by law. All fees must be in form of cash, postal money order, or bank draft, and not of check upon any local bank, other than Bismarck banks, since other checks are subject to a discount for collection.

(4) Applications, statements, maps, and all other papers must be in proper form, as prescribed by law and these regulations, before records will be made or certificates issued.

(5) The forms to be used for the enlargement or extension of a canal differ from those used in making an entirely new application. In making a request for forms, the source of supply, purpose, and character of the appropriation should be clearly stated.

(6) *Maps.*—All maps submitted shall be in duplicate; one copy must be on tracing linen, and the other may be either a blueprint or upon thin drawing paper or tracing linen. The size of each sheet shall be 18 by 18 inches, and lands in a single township only shall be shown upon one sheet, excepting by special consent of the state engineer. They may be sent to the State engineer rolled, but not folded. The scale of the map should be sufficient to show clearly the actual location of the structure or works, but should not be needlessly large. In case one sheet is not large enough, two or more may be used. In such cases the title of the map should be placed upon each sheet, and under it the statement, "this map comprises ——— sheets," giving the total number, the statement being followed by the number of the sheet, as "Sheet 1," "Sheet 2," etc., and the number of the township and range.

Permanent black ink must be used, as the maps are for permanent record. Higgins' waterproof or Windsor Newton's India ink are preferred.

(A) The map of the ditch shall show:

(*a*) Title, giving name of ditch or canal.

(*b*) Location of head gate, by course and distance to a Government corner, or if on unsurveyed lands to some natural object, so that the site can be easily found. True courses are to be used, the magnetic variations being stated also.

(*c*) Stream, the name thereof, from which water is diverted.

(*d*) Route and total length of ditch or canal.

(*e*) Lands crossed, with names of owners thereof.

(*f*) Lands to be irrigated, with names of owners thereof.

(*g*) Locations, with elevations thereof, of bench marks at the head gate or other suitable points.

(B) The map of the reservoir shall show:

(*a*) Title, giving name of reservoir.

(*b*) Location of initial point of survey, as in case of canal.

(*c*) Location of the dam, of the high-water line, and contour lines at appropriate intervals, and both the area within the high-water line and the capacity of the reservoir when filled to the high-water line.

(*d*) Stream, with name thereof, from which reservoir derives its supply of water.

(*e*) Location of ditches to and from reservoir.

(*f*) Legal subdivisions and ownership thereof.

(*g*) Lands to be irrigated and ownership thereof.

(*h*) A bench mark outside of reservoir, this bench mark being reference to the high-water line and other important elevations.

(*i*) The location of the outlet with reference to a Government corner; or, if upon unsurveyed ground, to some natural object, or to the initial point of survey.

(C) (*a*) Both ditch and reservoir maps shall have thereon a certificate of the engineer who made the survey.

(*b*) Plans of dams, cribs, or embankments must be drawn on longitudinal scale of not less than 1 inch to 200 feet, and for cross sections of not less than 1 inch to 20 feet. Timber, brush, and stones, where used, shall be shown in detailed plans, the scale of which shall be 1 inch to 4 feet. The plans for outlet and waste ways for reservoir shall be drawn on a scale of 1 inch to 4 feet, and are required for all dams over 5 feet high in a running stream or for any other dam over 10 feet high.

(*c*) The maps of reservoirs shall show the total area to be submerged and enough levels to permit of computing its capacity.

(*d*) For earth dams the slope must not be less than 3 to 1 for the front or water side and 2 to 1 for the back.

(D) Maps showing enlargements or extensions should show the original as well as the additional lines.

NOTES.

Lands may be shown by tinting with a colored pencil on the dull side of the tracing linen and this rubbed to an even tint by means of a medium hard rubber eraser. Where an enlargement application is

made the lands under existing rights through the same ditch should be shown in different colors. Colors which will not blueprint well should not be used. The preferred colors are green, orange, red, and yellow. Lettering on the map should be sparing, and superfluous matter should not be placed thereon. Indelible pencil or typewriter should not be used on tracing linen, since the oil in the cloth will cause these colors to spread, and in time it becomes almost obliterated. The affidavit of survey should be neatly lettered on the map. In preparing applications, the 40-acre subdivision, in which the head gate is situated, should be stated, and the bearing and distance to the nearest government corner should be given. In case of an enlargement, if the applicant is the owner of the ditch to be enlarged, he should so state; if not, the written consent of the owners must accompany the application. The following form of consent may be used:

I (or we) ———, the sole owner ——— of the ——— ditch taking water from ——— under permit No. ——, do hereby give my (or our) free and voluntary consent to the enlargement (or extension) of and to the use of water through the said ditch by ———, according to the terms of this permit to enlarge.

——— ———.

Subscribed and sworn to before me this —— day of ———, 190—.

Notary public (or other properly qualified officer).

(7) Each certificate signed by an applicant, surveyor, or engineer or other person must be sworn to before a notary public or other officer duly qualified to administer oaths.

(8) Application and permits are to be recorded in the State engineer's office in books provided for that purpose. One copy of the map will be filed and the other will be returned to the applicant after approval or rejection.

(9) The State engineer may, at his discretion, limit the time for the completion of work and the application of the water to the land to a reasonable period shorter than the maximum limit granted by law. Applicants should, therefore, request no more time than is required for the performance of the work when prosecuted with due diligence.

(10) It is within the discretion of the State engineer to fix a higher duty of water than 80 acres to the cubic foot per second in cases where it is known that this rate is too low. He can not, however, fix a lower duty.

(11) A cubic foot of water per second for 80 acres is equivalent in North Dakota to five-eighths miner's inch per acre. The limit of a water right for 160 acres, therefore, is 2 cubic feet per second, or 100 miner's inches, and is equivalent to a depth of water upon the land of about 3 feet in four months. In issuing the permit the State engineer will make a reasonable allowance in each case for the probable loss

between the diversion point and the delivery point at the upper edge of the land to be irrigated.

(12) Construction should not be commenced until the permit has been granted. (See first sentence in sec. 19, also sec. 54.)

(13) Construction must be prosecuted with reasonable diligence, as required by law.

(14) The State engineer must be notified promptly when the work of construction is one-fifth and completely finished.

THE SETTLEMENT OF LANDS UNDER IRRIGATION SYSTEMS.

On the larger irrigation projects in North Dakota, in preparing land for irrigation it is not necessary to contend with the sagebrush and greasewood common to the plains of most of the Western States, no greasewood whatever being found, and the sagebrush is small in size and on much of the land there is none. The soil is a deep, fertile loam. Ordinarily the land, when first broken, is seeded to flax and water is applied as well as possible. This irrigation does not generally benefit the first crop much, but it serves to assist in rotting the sod and in preparing the land for convenient deep plowing in the following fall or spring, and at the same time in average years produces a crop of sufficient value to repay the cost of labor and seed, and often a good profit besides. The means employed for leveling the surface whenever it is required is deep plowing, followed by good harrowing. There are no special devices used, each farmer depending on his own ingenuity. Some use scrapers when required, and others use a drag, but usually some cheap affair serves the purpose.

Under most of the projects the natural smoothness of the fields makes it possible to conduct water over large areas without leveling. However, it would be worth the outlay necessary to smooth the fields, because of the greater ease in the distribution of water and the increased yield of crops. The average cost of leveling and smoothing is about $2.50 per acre.

The most common method of applying the water is by furrow irrigation. A small ditch extends along the upper boundary of the tract to be irrigated, and in the lower embankment of this small ditch openings are made with the spade, and the water flowing through these openings is conducted to the furrows and flows down them. In irrigating such crops as corn, potatoes, and vegetables, the usual practice is to make furrows midway between the rows with a light plow. Openings connect the ditch bank with the head of furrows, a check dam consisting of earth or manure being placed in the head ditch opposite the lowest furrow of the strip.

The funds necessary for a settler to make a successful start on a farm under the different irrigation projects will not vary much. Farm units under the reclamation projects in the State so far estab-

lished are 160 acres. The land under the projects which is open to homestead entry must be entered under the provisions of the Reclamation Act, which imposes supplemental conditions. In general, these conditions are as follows:

Actual and continuous residence for a period of five years; at least one-half of the irrigable area of each farm unit must be reclaimed for agricultural purposes; persons who have resided upon and cultivated their lands during a period of five years will not thereafter be required to continue such residence and cultivation, and they may thereupon make final proof of reclamation and residence. The same credit for military service as granted under the terms of the homestead act is allowed soldiers, sailors, and members of the Marine Corps, but no patent shall be issued any homestead settler who has not resided upon, improved, and cultivated his homestead for at least a period of one year. Payments of the cost of construction of works are to be made in 10 annual installments without interest.

All projects have land held in private ownership by parties having land in excess of the farm unit allowed by the Reclamation Service which can be purchased at $15 to $35 per acre, and generally arrangements can be made with the owner or with local bankers whereby, if desired, this land can be purchased with payment down of $3 to $5 per acre and the balance extended over a term of years arranged to suit the convenience of the purchaser; or it can be purchased on the crop-payment plan, in addition to which he will pay annually in 10 equal installments, without interest, the cost per acre that the construction of the project has cost, together with the annual maintenance and operating charge.

From the above it will be seen that it is necessary for the intending settler to have some money. How much will depend somewhat on the family that he has and whether he homesteads the land or purchases it. In addition to the outlay for land it will be necessary to erect a small structure to serve as a dwelling until he is able to build to suit his taste. The cost of teams and implements sufficient to handle 160 acres of irrigable land will not be far from $1,000.

Previous knowledge of irrigation methods is not necessary. The Government has an experienced irrigator on each project whose business it is to teach the settler the proper method of irrigating. Many men who are wealthy to-day came to North Dakota with far less money, and, in fact, with little except pluck, energy, and perseverance. The settlement of the State has been made by such hardy races as the Norwegians, Swedes, Canadians, Germans, Russians, and native Americans from the older settled States. All well-minded, hard-working men are welcome, and to such the opportunities for obtaining a fortune in cultivating the irrigable lands of North Dakota were never better.

FUTURE DEVELOPMENT IN IRRIGATED FARMING IN NORTH DAKOTA.

The development along irrigation lines in North Dakota will take place much faster in the future than it has in the past. The Reclamation Service projects are an object lesson to the farmer outside of the projects, and he will soon be irrigating a small tract on his own land, either by pumping from wells or by damming a creek or coulée, the opportunities for which are numerous. In this work he can be assisted greatly by the Office of Experiment Stations of the United States Department of Agriculture, by the State engineer, and by the different experiment farms distributed throughout the State.

Among the problems needing investigation is the duty of water in the State. Under the irrigation code the maximum allowed is 2 acre-feet per acre per season. If with the average annual rainfall this amount could be decreased, water could be supplied to many more acres of land than is now contemplated. Evaporation tests from open bodies of water should be made through several seasons in order to determine the annual evaporation in the State. Irrigation experts should be sent among the farmers in the semiarid district to acquaint should be sent among the farmers in the semiarid district to acquaint them with the value of irrigation. Bulletins should be published on dam construction, especially in the silty soils of our stream valleys.

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